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"To the solid ground
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

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RESEARCHES ON RADIOACTIVITY.

Traité de Radioactivité. By Prof. Mme. P. Curie. Tome i., pp. xiii+426. Tome ii., pp. 548. (Paris: Gauthier-Villars, 1910.) Price, 2 vols., 30 francs.

NO more effective illustration of the rapidity of advance of accurate knowledge of radio-activity can be taken than a comparison of the two books published on the subject by Mme. Curie, at an interval of seven years. The first, published as a thesis for the doctorate of science in 1903, was a small volume of 142 pages, and gave an account, not only of her own work, but of most of the important facts known in radio-activity at that time. The second, published at the close of 1910, consists of two volumes, containing in all nearly a thousand closely-written pages, and giving an orderly and systematic account of the large mass of data that has been accumulated in the interval. The remarkable rapidity of advance of this new branch of science largely results from two factors—the discovery and isolation of radium by Prof. and Mme. Curie, and the development of the transformation theory in 1903.

The discovery of radium gave an opportunity to the investigator of obtaining intensely radio-active material, in which the typical radio-active effects are shown on a very marked scale. The remarkable properties of radium attracted the attention of the scientific world, and gave a great impetus to the study of radio-activity. On the other hand, the transformation theory has proved an invaluable guide to the investigator in disentangling the apparently complicated processes occurring in radio-active matter. It offers a rational explanation of practically all the experimental facts that have been discovered, and has been instrumental in bringing to light a number of unsuspected relations of great importance.

This work represents, with additions, the course of lectures on radio-activity given by Mme. Curie in the Sorbonne. The first chapter is devoted to an account of the conduction of electricity through gases, and the second to a description of the methods employed in radio-active measurements. The latter contains a somewhat detailed account of the theory of the electrometer and of the quartz piezo-electrique devised by J. and P. Curie. Chapters iii. and iv. include an account of the general radio-active properties of uranium and thorium, and of radio-active minerals, and a very complete account of the methods of isolation of radium and polonium and other radio-active materials. This chapter will be read with especial interest, as it is largely an account of the author's well-known discoveries. The next three chapters deal with the radio-active properties of the emanations, and of the active deposits which are derived from them. A very full description is given of the methods employed in determining the molecular weight of the emanation by diffusion methods, and also a clear account of recent work upon the purification of the radium emanation, the determination of its volume, and of its physical and chemical properties. In chapter viii., after a review of the various theories proposed, the transformation theory is adopted, and the mathematical theory of successive transformations is given. Then follows a long chapter of more than 200 pages, giving a systematic account of the nature of the radiations from radio-active bodies, followed by a discussion of the general physical and chemical effects shown by the radiations, including the production of helium from radio-active matter, and an account of the experiments which have been made by Ramsay and others to test whether the radiations from active matter are able to transform inactive elements. After a discussion of the various experiments, Mme. Curie sums up as follows:—

> "En resume, on peut considérer qu'il n'y a pas encore actuellement de raisons suffisantes pour admettre que la formation de certains éléments puisse être provoquée à volonté en présence de corps radioactifs. La production d'hélium reste acquise; mais elle est reliée à une propriété essentielle des éléments radioactifs et n'est pas influencée par l'intervention de l'expérimentateur."

Chapter xi. gives an account of the methods of measurement of heat emission of the radio-active substances, while the next four chapters deal with successive transformations occurring in uranium, thorium, radium, and actinium, followed by an account of the origin of radium and the discovery of ionium, and the discussion of the general connection between the radio-active series. The last chapter is devoted to a consideration of the radio-activity of the earth and atmosphere.

An excellent portrait of Pierre Curie is given in the frontispiece. Several interesting reproductions are included at the end of the volume in illustration of the photographic effects of the various radiations. Carefully prepared tables are included in the text, giving the important radio-active constants, while a table of exponential values is added for convenience in calculating the decay and growth of the radium emanation.

In these two volumes, written in a clear and interesting manner, Mme. Curie gives a full and complete account of practically all the work of importance that has been done in radio-activity. It is a storehouse of accurate information. The author has shown judgment in the selection of data and in discussion of points at issue. The chemical methods of separation of radio-active products are in most cases briefly given, while a detailed account is included of the methods of separation of radium and of polonium. This is excellent so far as it goes, but it does not fill the pressing need at the present time of a practical book on the methods of separation and purification of the numerous radio-active products. Such an account should prove of the greatest value both to chemists and physicists, for it is becoming more and more important in many lines of work that the investigator should be able to separate and concentrate the various radio-active products. Such an account can only be written by an expert both on the physical and chemical side who has himself worked over the subject, for more than a compilation of chemical methods is required.

It is always a difficult matter in a work of this character, which treats of a rapidly growing subject, to give full credit to pioneer discoveries, and at the same time to do justice to later work of a more detailed and accurate character. Mme. Curie has, to a large extent, overcome this difficulty by giving a fairly detailed account of the original experiments, and a more condensed statement of subsequent work.

There is very little to criticise and much to admire in this notable work. It is remarkable what little difference of opinion exists among radio-active workers on the interpretation of the main phenomena. This is no doubt mainly a result of the general adoption of the theory of atomic disintegration, for on this theory only one explanation is in most cases admissible. While there is a general agreement on the fundamental points, there is naturally room for wide difference of opinion on matters still under investigation. This is well illustrated by the conflicting views that are at present held on the difficult question of the nature of the emission and of the absorption of the β and γ rays by active matter. The advocacy of rival views on such questions is in many cases a great advantage, for it gives an incentive to a more accurate and complete investigation of the problem under consideration.

While the reviewer finds that he is in substantial agreement with all the main conclusions of Mme. Curie, there are a few minor points to which attention may be directed. Mme. Curie includes radio-uranium as a possible product of uranium, although a note of interrogation is attached. She certainly makes a better case for its existence than is given in the original publication; but until more definite information is forthcoming it does not appear desirable to include it in the uranium series. The products radium E_1 and radium E_2 are retained, although later work of Antonoff has indicated conclusively that only one product of period about five days which emits β rays can be present. The discovery of ionium is credited to Rutherford and Boltwood; it should be Boltwood. The original suggestion that lead is a final product of the transformation of radium is attributed to Rutherford. It should be Boltwood. The term "radio-active induite" is used widely throughout the work. While the use of this expression is historically justified, it is a misnomer, especially when used in reference to radio-active *matter* deposited from the emanation. The term "active deposit," which has come into general use, is a very convenient substitute and it is desirable that the original names, "induced," or "excited," activity, should disappear from the literature.

The lack of a name- or subject-index is a serious drawback to the usefulness of this treatise. The references to literature are incomplete, the name of the journal and the year of publication alone being given.

As an account of a youthful branch of science, the present treatise may appear somewhat lengthy; but it must not be forgotten that the subject of radio-activity now covers a very wide field of work. It has to treat, not only of the nature of remarkable types of radiation which are emitted, but also of the origin and physical and chemical properties of more than a score of new transition elements. In addition, it has to deal with the distribution of radio-active matter in the earth and atmosphere, and its bearing on atmospheric electricity and on problems connected with geology. Unless this treatise is to become unwieldy in size, it will be necessary in future editions, where much new work has to be included, to adopt a policy of more rigid selection and compression of the experimental data to be discussed. No doubt as our knowledge of the various questions becomes more definite, it will not be so difficult as at present to give a complete review of theory and experiment within reasonable limits of space.

The present work will be read with the greatest interest by all workers in radio-activity as an authoritative account of the subject from one who has made notable contributions to its history. The book is essentially written for the investigator rather than for the ordinary student, and will be of the greatest service to the former as a complete and accurate review of all important publications on the subject. Every reader will recognise the great labour and patience involved in writing a complete treatise on such a rapidly growing subject, and Mme. Curie is to be congratulated on the success of her efforts.

This treatise is a noteworthy contribution to the literature of this new and fascinating field of scientific inquiry, and redounds to the credit of Mme. Curie, and to the nation which has taken such a fundamental and prominent part in the development of radioactivity.

E. R.

DYNAMO-ELECTRIC MACHINERY.

The Dynamo: Its Theory, Design, and Manufacture. By C. C. Hawkins and F. Wallis. Fifth edition. Re-written, revised, and enlarged. Vol. i., pp. x+542. Vol. ii., pp. viii+543–1134. (London: Whittaker and Co., 1909.) Price 21*s.* net, two vols.

THE increase in the size of Messrs. Hawkins and Wallis's book is a good indication of the progress that has taken place in the practical development of the dynamo. Little or no addition has been made in the interval to the fundamental theory of direct-current and alternating machines; an immense advance has been made in the mastery of the thousand and one details of selection of materials and methods of construction of machines for different purposes.

Vol. i. is mainly theoretical, and contains statements regarding the physical facts and theories on which electric generators and motors are based. The treatment of the magnetic circuit, of self-induction and alternating currents, the classification of dynamos, the magnetic properties of iron, and so forth, strike one as exceedingly satisfactory. In general there is a clear perception of what constitutes a proof of a theorem and what a mere illustration or representation of results. It is possible to frame graphical proofs of theorems of electromagnetism, as of dynamical theorems regarding stresses in the members of a girder, and it is a good thing to do so; but many so-called graphical "proofs" are mere illustrations of results which have been so far only satisfactorily established by analysis. The graphical representation displays to the eye connections of things set forth in equations, and so far as possible this should be done in all departments of mathematical physics; but the student should not be led to imagine that he has got to the root of the matter, when he realises that $\sqrt{R^2+n^2L^2}$ is the length of the hypotenuse of a right-angled triangle, the lengths of the sides of which are R and nL. As it seems to us, Messrs. Hawkins and Wallis have given a very happily blended analytical and geometrical discussion.

The analogy of inductance and capacity to inertia and the slackness of a buffer spring, of the electrokinetic energy $\frac{1}{2}Li^2$ to the kinetic energy of a carriage, and the analogy of the dissipation of this kinetic energy, when the carriage is brought to rest by collision with the buffers, to the break of a circuit containing a condenser, gives a clearer idea of what happens than general statements, and we should have liked to see some such practical "engineering" illustrations in the chapter on self-induction.

Then it is a little difficult to distinguish, as the authors seem to do on p. 69, between "the current itself," and the magnetic field which it produces. Is it not all one phenomenon? One may try to distinguish between the current—the motion of electrons (or, as someone has illuminatingly called them, the essential singularities that are at the root of all electrical action)—and the magnetic field, but is it possible to do so really? One cannot have a vortex filament in an infinite fluid without the irrotational flow which constitutes its field. It may be said that by twisting the outward and inward wires of a circuit together or by putting one inside the other, a field can be avoided; but the assertion is only true for space external to the conductors. A field can only be avoided altogether by making the going and returning conductors absolutely coincident, in which case there is no current.

The molecular theory of magnetism may possibly require modification in view of still more modern theories of the electrical constitution of matter; but it has done much service in clarifying the ideas of students of magnetism, and it still substantially fits the facts. How often did one find in elementary books the higgledy-piggledy arrangement of molecular magnets pictured, to explain to the reader the constitution of a body in the neutral state? It never seemed to occur to the writers that these magnetic molecules must act on one another, and that the perfectly fortuitous arrangement was unlikely to have been set up, or to remain if it were. The closed chains were in the minds of many; the exhibition of Ewing's model made clear how these closed chains led to the observed magnetisation curves.

During the last year or two much further work on magnetic induction in iron and alloys has been done, and on the influence of treatment of different kinds: it will be for the dynamo builder and user to examine whether any part of the work is likely to be of use to them. But no doubt for a long time the knowledge that has been accumulated of the constants of steel of different kinds, in stampings of different thicknesses, will be sufficient for their needs.

Chapters xiv. and xv. of the first volume, on "Field-Magnets" and "The Ampere-Turns of the Field" respectively, are exceedingly instructive and interesting, and are, of course, of great importance, for the proper design of a dynamo or motor for a given specified purpose depends entirely on a due appreciation of the principles laid down in every sound discussion of this subject.

In vol. ii., after a discussion of armature reaction which seems adequate, a long chapter (110 pages) is given on "Commutation and Sparking at the Brushes." This important subject is very fully dealt with, apparently with a thorough appreciation of all that has been done on the subject of commutation and the factors on which sparking at the brushes depends, and also of the quantitative laws of the matter so far as these have been theoretically and empirically compiled.

Chapters follow on the "Design of Continuous-Current Dynamos and Alternators," and these are based on a full description of all the various forms of armatures and field-magnets in use in the various types.

The book, if a little heavy (in avoirdupois), is beautifully printed and magnificently illustrated with 594 pictures, diagrams, and cuts of different sorts, and reflects credit on authors and publishers alike.

A. G.